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Review on fuel economy standard and label for vehicle in selected ASEAN countries

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ABSTRACT

Sustainable supply of energy at affordable prices is vital to ensure the human development. ASEAN is committed pursuing for a clean and green region with fully established mechanisms for sustainable development to ensure the protection of regional environment, resources and the high quality of people's life. Nowadays, energy use in the transportation sector represents an important issue in ASEAN countries. Therefore, it is believed that the introduction of fuel economy standards and labels is the key to save energy in this sector. Fuel economy standards and labels are relatively cheap measure to influence consumer behaviour and to induce car manufacturers to produce more efficient vehicles. Fuel economy standards and labels for vehicle are being implemented in many countries around the world to save fuel consumption and mitigate CO_2 emission. This paper is a review on fuel economy standard and labels for vehicle in some selected ASEAN countries such as Singapore, Indonesia, Malaysia, Philippines, Thailand and Vietnam. It has been found that Singapore is the leading country in ASEAN that has implemented fuel economy standards and labels. Moreover, it has been found that the implementation of cleaner fuels standard play a crucial role in protecting public health and the environment from transportation sector emissions. The most common alternative fuels used in ASEAN are biodiesel, ethanol, methanol, propane, hydrogen and natural gas.

Contents

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1. Introduction

Sustainable supply of energy at affordable prices is vital to ensure the human development. Nowadays, energy use in the transportation sector represents an important issue in ASEAN countries. Therefore, it is believed that the introduction of fuel economy standards and labels is the key to save energy in this sector. However, these standards and labels need to be complementary or at least not undermine other energy and emissions-related policies and programs of the ASEAN member countries. In this region, the designed fuel economy standards most importantly lie in the form of reduced fuel subsidies. These standards will be more helpful and effective if the member countries try to link air pollution mitigation efforts with fuel economy standards initiatives. In 1992, the ASEAN Environmental Improvement Program (ASEAN-EIP) was established and funded by the United States Agency for International Development (USAID). The program approach was similar to present concepts of cleaner production (CP) which addresses the total production process and its upstream and downstream consequences. This attempt aims to mitigate emission and create an awareness to environment [1]. ASEAN is committed to pursuing for a clean and green region with fully established mechanisms for sustainable development to ensure the protection of regional environment, resources and the high quality of people's life. Emission standards for new or in-use motor vehicles have been issued in ASEAN countries as benchmark whereby compliance is enforced by regulatory agencies within the respective governments [2]. However, emissions from uncontrolled vehicle in-use have detrimental effects on air qualities, and thus the consumers have to cover the costs related to health problems. Taking into account the health costs, policy implementation on air pollution reduction will create on economic development. In other words, the implementation of this policy seem to be in the long run [3]. The ASEAN can also assets a stronger voice to vehicle/engine manufacturers to adopt government policies. For instance, the Thai auto market has responded favourably to tax incentives provided by the government for producing eco-cars. This has encouraged manufacturers of low-emissions cars to produce in Thailand. Furthermore, Indonesia plans to follow the footsteps of Thailand by offering incentives for the production of fuel-efficient cars, and Malaysia's lead with national car program such as the proton [4]. Compared with other regions, the United States and Europe have been successful in implementing fuel economy and greenhouse gas emissions standards. Moreover, in 1999 Japan has established fuel efficiency standards for light duty vehicles (gasoline and diesel vehicles) followed by Korea, Canada and China [5–11].

The association of Southeast Asian Nation (ASEAN) was established on 8th August 1967. Currently it consists of ten members; Malaysia, Indonesia, Philippines, Singapore, Thailand, Brunei Darussalam, Cambodia, Lao PDR, Myanmar and Vietnam. The map of ASEAN is given in Fig. 1 [12]. The rapid economic growth in ASEAN countries for the last two decades has raised the concern of sustainable energy development. The region has enormous renewable energy development, energy efficiency improvement, sustainable transportation and utilization. Cooperation in energy among the member countries are promising factors towards successful sustainable energy development in the ASEAN countries [13].

Energy use in the transportation sector is an important issue in ASEAN countries especially in the increasing threat of global warming and climate change. This has lead to focus on the relationship between economic growth and environmental pollution [14]. As shown in Fig. 2 [12], the road transport sector has an increasing share of total energy consumption in ASEAN countries. As this trend continues, the growing fuel consumption from the transport sector will have a significant impact on national energy security.

Fig. 3 shows the import of petroleum products by some selected ASEAN Economies [12]. Since 1994, the consumption of oil in the ASEAN region exceeds the production as illustrated in Fig. 4 [15]. This will impose a pressure on the ability of ASEAN countries to use their financial resources for national development as they are needed for importing crude and processed oil.

In 2009, the Indonesian energy outlook recognizes that oil was the largest single source of energy (48%) followed by natural gas (26%), coal (24%) and renewable (2%) as shown in Fig. 5. Moreover, it is expected that total fossil fuels consumption will increase by a percentage 52% by 2025 [15]. In 2007, the largest consumer of fossils fuel was the industrial sector which reaches 48% from total national energy consumption followed by the transportation sector (33%) as shown in Fig. 6 [15].



Fig. 1. The ASEAN member countries [12].

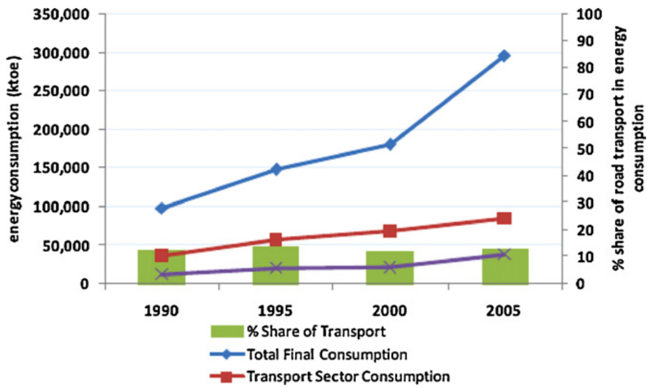


Fig. 2. Energy consumption from transport in ASEAN [12].

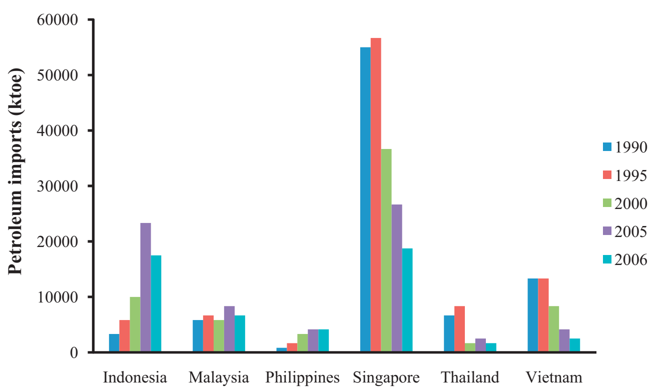


Fig. 3. Petroleum imports of selected ASEAN countries [12].

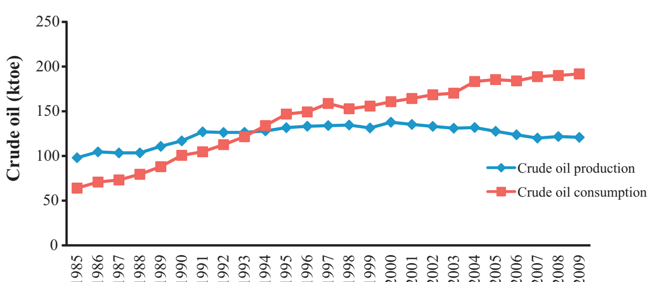


Fig. 4. Crude oil production and consumption in ASEAN between 1985 and 2009 [15].

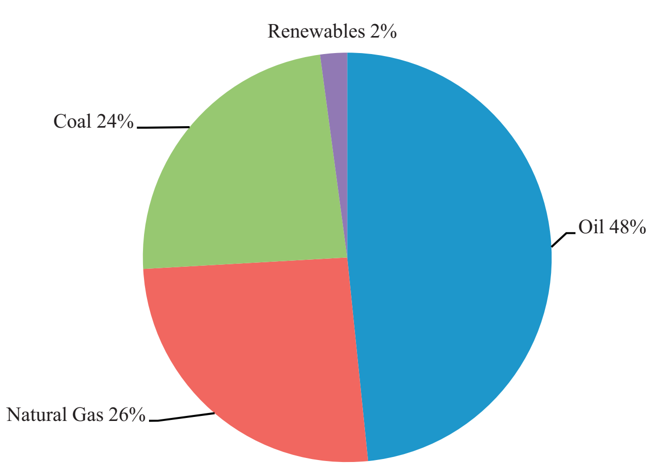


Fig. 5. Statistics of Indonesia energy consumption by fuel in 2009 [15].

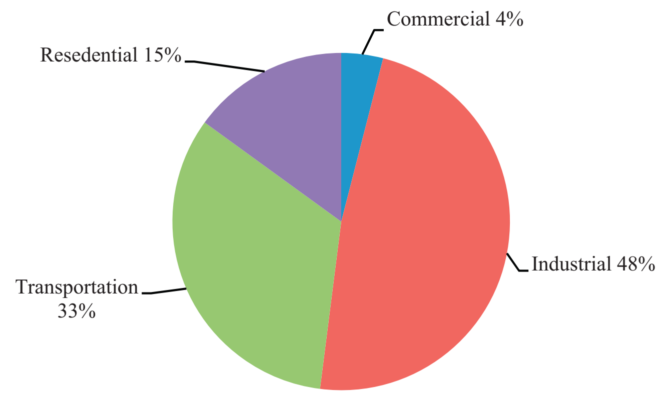


Fig. 6. Statistics of Indonesia energy consumption by sector in 2007 [15].

The Indonesian government has maintained the market prices of fossil fuels to enable all strata of society to easily procure this fuel. However, this country is moving away from subsidies to standards and labelling programs [16]. Starting from 2005, these programs have successfully cut down exhaust emissions gases such as CO and NO_x and reduce CO_2 emissions by 25%. Theoretically, fuel economy standards and labels show the other side of vehicle efficiency that are more powerful, more comfortable, faster and economical [17].

2. Motor vehicle

Road transport is the key element in the mobility of goods and people [12]. Globally, road transport is the major oil consumer and is one of the fastest growths of energy end consumer. This sector is account for about 60% of world oil consumption and road transport alone accounts for about 80% of the total consumption in transportation sector. Transportation sector accounts for around 25% of total world carbon dioxide (CO_2) emissions. Within this sector, road transport, accounting for 10% of global GHG emissions. Furthermore, it is expected that the projected road vehicle energy use and CO_2 emissions would rise through to 2030 at an average of 1.4% and 1.3% per annum, respectively [10]. At the same year, the share of the world's population living in developing regions will likely reach 81%. As the International Energy Agency (IEA) reports, in developing Asian countries, an average growth rate of 3% is projected for energy use compared with 1.7% for the entire global economy. Energy consumption in ASEAN is expected to increase from 200 million tons of oil equivalent (MTOE) in 2000 to approximately 580 MTOE in 2020 with the transportation sector experiencing the highest growth in consumption of 5.1% annually, corresponding to an equivalent growth in CO_2 emissions. According to the projection, this increase in regional demand will account almost 40% of the world total [12,14,18,19]. Based on this estimated growth scenarios, the ASEAN motorization levels (number of vehicles per 1000 people) will continue to be higher than India and China for the next two decades as shown in Fig. 7 [12].

Fuel economy policies and measures will provide an opportunity for policy makers to reduce fuel consumption, providing savings for both importing and non-importing countries as well as contributing to fuel security. Moreover, such policies and measures will contribute in reducing CO_2 emissions from the transport sector [20].

2.1. Vehicle background

The numbers of diesel passenger car are increasing rapidly in some European countries. In 2000, they made up in excess of 30% of total passenger cars in France, Austria and Belgium. This trend is expected to continue in the future, and in response, the EU has

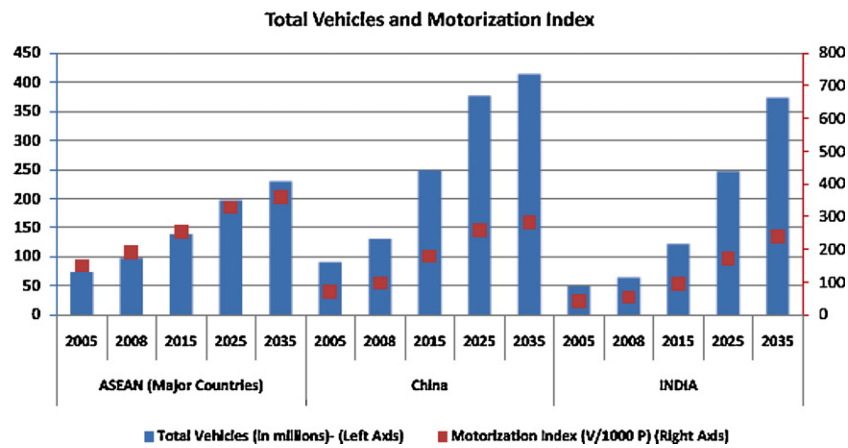


Fig. 7. Motorization index in ASEAN, China, and India [12].

Table 1
New vehicle standards in ASEAN region [23].

Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Indonesia							Euro 1 (proposed)						Euro 2 (proposed)			
Malaysia			Euro 1			Euro 2										
Philippines									Euro 1							
Singapore	Euro 1						Euro 2									
Thailand		Euro 1			Euro 2			Euro 3					Euro 4			
Viet Nam				Euro 1												

introduced more stringent diesel emission standards which can only be met through a combination of improved engine technology, and of higher fuel quality [21]. China and India have also seen an upward surge in urbanization with rapid economic growth, resulting in a rapid increase in the demand for personal mobility and the number of motorized 2–3 wheelers and cars. These countries have developed and implemented fuel economy standards which contributed to a potential fuel savings. Other Asian countries have developed and implemented a variety of vehicle-related policies, including taxation. However, none appears to have issued policies that require or encourage CO_2 reduction or fuel efficiency improvement in new cars and other light-duty vehicles [22]. The new vehicle standard in Asia is shown in Table 1 [23].

Motorization in ASEAN countries is the main driver for transport externalities. Fig. 8 shows the growth of motor vehicles by mode in six ASEAN countries [12]. Current estimates show that if the reference scenario pervades in the future, the vehicle increase will not only come from motorcycles, but also from personal cars and light-commercial vehicles, in descending order.

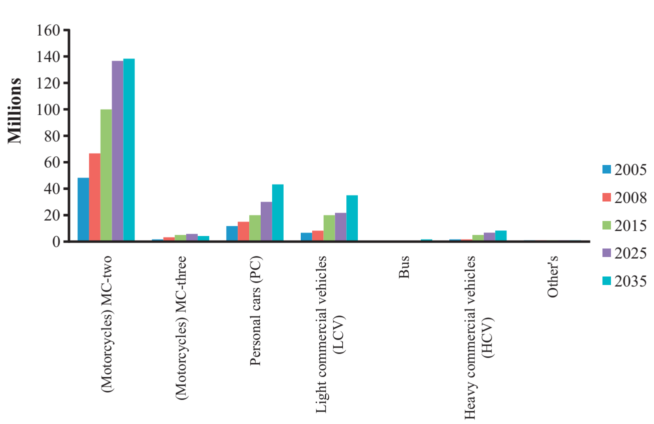


Fig. 8. Growth of motor vehicles per mode for 6 ASEAN countries [12].

In strengthening the automobile market while promoting sustainable mobility, ASEAN is moving towards the abolition of regional tariffs, harmonization of automotive technical regulations, mutual recognition of certification, streamlining of customs procedures and distribution systems, fostering of supporting industries and human resources, promotion of safety, greater environmental protection, and other strategies [12].

2.2. Vehicle fuel efficiency

Vehicle energy use and loss vary greatly according to vehicle technologies and drive cycles. Fig. 9 shows the flows of energy in modern passenger cars [24,25]. The opportunities to improve vehicle fuel efficiency are available via the following changes [26]:

(i) Engine and vehicle technology.
(ii) Transport fuel mix.

The technical efficiency of vehicle was noted to be a potential measure to encourage the uptake of more fuel efficient, low carbon emission vehicles. Fig. 10 shows strategies for reducing vehicle emissions and improving fuel economy in real "on-road" fuel efficiency which also involve driving behaviour [27]. To attain most effective outcome, technical efficiency improvements need to be combined together with other policies such as those to increase on-road fuel efficiency, reduce the distances travelled by private vehicles, change the mix of vehicles providing trips, promote conversion to fuels with lower carbon content, and shift trips to public transport [12].

The available technologies for improving vehicle fuel efficiency are continuously progressing. Therefore, currently available technologies can be implemented more widely and this further improve the economy of the vehicle [28]. In addition, emerging

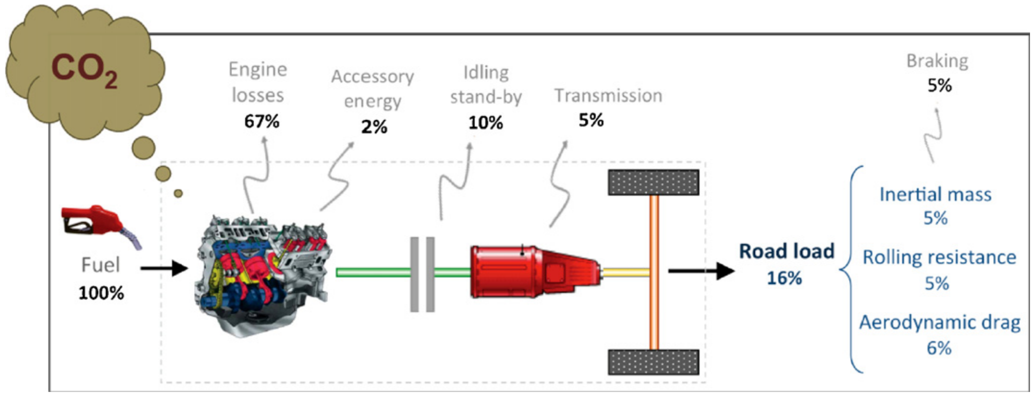


Fig. 9. The ultimate design potential vehicle "road load" for reduction of CO_2 emission [24,25].

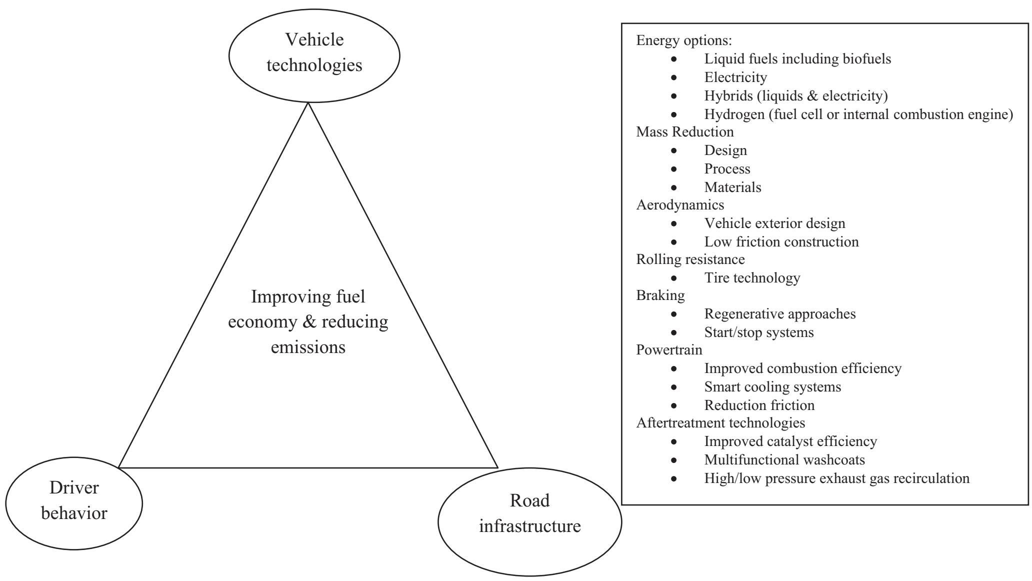


Fig. 10. Strategies for reducing vehicle emissions and improving fuel economy [27].

technologies now is the late stages of development and will likely to be introduced over the next several years and will be increasingly utilized to improve efficiency of the vehicle. Advanced technologies currently in the Research and Development stage and will become available over the next one or two decades [29]. There are many promising CO_2-reduction technologies for vehicles, some of these technologies are presented in Table 2 [24].

Table 2
GHG reduction technologies [24].

Area	Technology or mechanism for CO_2 reduction		Potential CO_2 reduction	U.S. adoption in 2008 fleet
Power train	Engine	Variable valve timing or lift	2–8%	53%
		Cylinder deactivation	3–6%	6%
		Turbo charging	2–5%	2%
		Gasoline direct injection	8–15%	4%
		Compression ignition diesel	15–40%	0.10%
		Digital valve actuation	5–10%	0%
		Homogeneous charge compress ignition	15–20%	0%
	Transmissions	6+ speed	3–5%	21%
		Continuously variable	4–6%	8%
		Dual-clutch, automated manual	4–8%	1%
Vehicle	Aerodynamics		5–8%	–
	Tire rolling resistance		2–8%	–
	More efficient auxiliaries (steering, air conditioning)		2–10%	–
	Mass-reduction	Advanced material component	5–10%	–
		Integrated vehicle design	10–20%	–
	Hybrid systems	Stop–start mild hybrid	5–10%	<1%
		Full hybrid electric system	20–50%	2%
	Electric-drive	Plug-in capable electric vehicles	30–75%	0%
		Fuel cell vehicles	30–75%	0%

Table 3
Urban air quality in the ASEAN countries [13].

Urban air quality	WHO guidelines (mg/m^3)	ASEAN range (mg/m^3)
Total suspended materials	100	95–270
SO_2	50	<50
NO_2	50	<50
Leaded gasoline	Phased out in much of ASEAN; planned for the rest by 2001–2005	
Lead in ambient air	Before implementing unleaded gas	After implementing leaded gas
Malaysia and Thailand	1.4–1.5	0.1 mg/m^3
Singapore	0.5–0.6	0.1 mg/m^3

Considering the feasibility of technologies such as in power train and body construction, changes in vehicle design could have major implications on the organizational structure of the industry for introduction of different vehicle classes. With vehicle mass-reduction technology, CO_2 emissions are decreased due to reduced vehicle road loads (i.e., inertial acceleration, rolling resistance, and grade). For instance, a 20% mass-reduction will decrease 12–16% of CO_2/mi. Currently, modern vehicles are generally 15–25% efficient and less energy needed for vehicles [30].

2.3. Gas emissions standard in the ASEAN region

The transport sectortation is responsible for 23% of the world's carbon dioxide (CO_2) emissions and 13% of global GHG emissions [12]. In ASEAN, the emissions of carbon dioxide (CO_2) from the transportation sector has increased from 419.3 million ton in 1990 to reach 1062.4 million ton in 2009, with an average annual growth rate of 3.4% [15]. Although the share of CO_2 emissions attributable to transport sector of developing countries is currently low, emissions are expected to increase by 45.6% between 2005 and 2030 [12]. Urban air pollution is a significant issue in many developing countries, including ASEAN countries. Most of metropolitan cities have already crossed the total suspended material level set by World Health Organization (WHO) guidelines shown in Table 3 [13]. However, other emissions such as lead, sulphur and nitrogen dioxide are still below provided by WHO guidelines. Most of the member countries have already introduced the unleaded gasoline has been used widely in most of the member countries. Since then, the level of lead in ambient air quality has improved considerably as shown in Table 4 [13] and the air quality standards has been implemented in most of the countries [13,31].

The environmental degradation is primarily due to emissions from fossil fuel combustion in the region. About 90% of the ASEANs primary commercial energy requirement is fulfilled by fossil fuels (coal, oil, and gas). The CO_2 emissions in the region are increasing; road transport is not only a significant contributor to GHG emissions but also to air pollutant emissions. Table 5 shows the trend of vehicle standards emissions in selected ASEAN countries in the region over the last decade [13,20]. These measures can be taken to abate air pollution from road transport, like developing roadmaps for implementing vehicle emissions standards. Table 6 and Fig. 11 show the current and planned vehicle emissions standards in selected ASEAN countries [12].

Table 4
Implementation of unleaded gasoline in the ASEAN countries [13].

Countries	Unleaded introduced	Completely unleaded
Brunei	January 1993	March 2000
Cambodia	N/A	N/A
Indonesia	1997/1998	1999/2000
Lao PDR Malaysia	N/A 1991	N/A
Myanmar	N/A	N/A
Philippines	1993	2001
Singapore	January 1991	July 1998
Thailand	May 1991	January 1996
Vietnam	May 2000	January 2005



Fig. 11. Particular matter (PM) emissions in ASEAN – road transport [12].

3. Fuel quality standards

Fuel quality standards play a crucial role in protecting public health and the environment from transportation sector emissions. It is often viewed as an important component of an overall plan to improve air quality. Between 2004 and 2009, the prices of fuel experienced large fluctuation. In addition to fuel price fluctuations, cost uncertainties arise due to the emission of greenhouse gas (GHG). Therefore, GHG are strongly correlated with the type of fuel. This correlation gives a rationale for policy proposals such as carbon taxes, which is translated directly into changes in the price of fuel [32]. The implementation of cleaner fuels standards has an immediate impact to the environment when using in both new and existing vehicle fleets. For instance, the reduction of sulphur to near-zero levels is prerequisite for any air pollution reduction strategy. In the United States, lead content ranges in 0.24 g/l of gasoline. In January 2008, some Europe Union countries such as Greece, Italy and Spain introduced off-road diesel sulphur content permissible maximum limit to be 1000 mg/kg [33,34].

Fuel quality regulations and specifications vary from one country to another. Tables 7 and 8 illustrate specifications for unleaded

Table 5
Vehicle emission standards and time to enter into force in ASEAN [20].

Countries	Euro I	Euro II	Euro III	Euro IV	Euro V
Indonesia	–	Early 2006	1st Q 2007	2012	–
Malaysia	–	Mid 2006	–	2010	–
Philippines	–	December 2006	–	2010	–
Singapore	–	2005	–	October 2006 (diesel)	–
Thailand	–	–	Early 2005	2010	–
Vietnam	–	July 2007	–	2012	–

Table 6
The vehicles emissions standards in ASEAN countries [12].

Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Indonesia											Euro 2										
Malaysia			Euro 1													Euro 2			Euro 4		
Philippines									Euro 1				Euro 2								E4
Singapore[a]	Euro 1						Euro 2														
Singapore[b]	Euro 1						Euro 2														
Thailand	Euro 1						Euro 2			Euro 3								Euro 4			
Viet Nam												Euro 2									

aGasoline
bDiesel

[a]Gasoline.
[b]Diesel.

Table 7
Gasoline specifications in some selected developing countries [35,36].

Country	Property Ron (value min)			Property Sulphur (mg/kg or ppm, max)		
	Reg	Prem	Supreme	Reg	Prem	Supreme
Bangladesh	80	95		1000	1000	
India	88	93		1000	1000	
Malaysia	92	97		1500	1500	
Philippines		93		1000		
Pakistan	80	87	97	2000	2000	2000
Thailand	87	95		1000	1000	1000
Kenya	83	93		500	500	
Tanzania	87	95		1500	1500	
Argentina	83			500		
Bolivia	85	95		500	500	
Colombia	81	87		1000	1000	
El Salvador	87	95		1500	1500	
Guatemala	87	95		1500	1500	
Honduras	87	95		1500	1500	
Mexico		95		250–300	250–300	
Nicaragua	87	95		1000	1000	
Panama	87	91		1000	1000	
Paraguay	85	97		1000	1000	

gasoline and fuel quality standards (level of sulphur in diesel) in selected developing countries [35,36]. In Senegal, a decree issued in 2002 stated that the maximum lead content must be reduced from 0.8 to 0.15 g/l in 2003. Nigeria has also worked to reduce lead content from 0.45 g/l to 0.15 g/l in 2002 to lead-free in 2003 [35]. Sulphur limits, especially in diesel, tend to be very high in Pakistan, Malaysia, India, Bangladesh, Thailand, El Salvador, Guatemala, Honduras, and Nicaragua. While in, Mexico, the maximum allowable limit of sulphur in fuel is far lower than in countries mentioned above [8]. Meanwhile, China is taking aggressive steps towards containing hazardous components in fuel. In 1998, the local government in Beijing successfully phased out leaded gasoline. At present, sulphur content ranges from 150 ppm to 500 ppm for gasoline and from 2000 ppm (recommended 500 ppm) for diesel fuel in Beijing [37,38].

4. Promotion of alternative fuels in ASEAN

Alternative fuels are mainly renewable fuels that derived from resources other than petroleum and diesel fuels. The advantages of these types of fuels are that they emit less emission and more economically viable compared to fossil fuels. The most common alternative fuels are propane, ethanol, methanol, biodiesel, hydrogen and natural gas. The main content of natural gas (up to 96%) is methane. Natural gas use for vehicle and its the most common

Table 8
Fuel quality standards in ASEAN (levels of sulphur in diesel [35,36]).

ASEAN Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cambodia					2000				1500								
Indonesia	5000										3500				350		
Malaysia	5000			3000			500[c]			500[d]							50
Philippines	5000					2000			500								
Singapore	3000			500							50						
Thailand	2500			500					350		150				50		
Vietnam	10000											500					

>500 ppm.
51–500 ppm.
<50 ppm.

Table 9
Brief overview of experiences from selected fuel economy initiatives [12].

Country/region	Summary
United States	In May 2009, The US unveiled revamped national policy aimed at both increasing fuel economy and reducing greenhouse gas pollution for all new cars and trucks sold in the United States. The new standards, covering model years between 2012 and 2016, and ultimately requiring an average fuel economy standard of 35.5 mpg in 2016, are projected to save 1.8 billion barrels of oil over the life of the program with a fuel economy gain averaging more than 5%t per year and a reduction of approximately 900 million metric tons in greenhouse gas emissions. This would surpass the CAFE law passed by Congress in 2007 required an average fuel economy of 35 mpg in 2020. In May 2010, announcements were made by the US government on introducing stricter fuel economy requirements for trucks.
European Union	In 1998/1999, the EU reached a voluntary agreement with the European Automobile Manufacturers Association, Japanese Automobile Manufacturers Association (JAMA) and Korean Automobile Manufacturers Association (KAMA) to work towards a target of 140 g CO_2/km for passenger cars. Reports suggest that emissions from the average new car sold reached 163 g CO_2/km in 2004. Since the measure had limited success, in June 2007, the Council of Environment Ministers formally adopted a resolution on mandatory targets for passenger cars of 120 g CO_2/km by 2012. This target would be met through an "integrated approach", whereby car manufacturers would achieve 130 g/km through technical improvements in vehicles and engines and the remaining reduction of 10 g/km would be achieved through other measures.
Canada	Canada has a long history of voluntary agreements with the auto industry, which the government and industry initiated in the late 1970s to avert legislation. The initial program was designed to provide information on fuel consumption rates to consumers, and to improve the fuel efficiency of new vehicle fleets. In November 2007, a law was passed to enhance the Canadian federal government's authority to regulate vehicle fuel efficiency, and regulations will take effect in 2011. The new mandatory fuel standards for cars and light trucks will be harmonized with current and future US fuel regulations aimed at curbing carbon emissions.
Japan	Regulatory "Top Runner" standards and the mandatory display of energy efficiency values were enabled in 1998. The standards have been introduced for LDVs (1999), LPG vehicles (2003) HDVs (2006). It is also mandatory to ensure labelling of vehicles. The standards can be considered as effective as there is a strong disincentive for the customers in the form of progressively higher taxes levied based on the gross vehicle weight and engine displacement of automobiles when purchased and registered.
South Korea	The Average Fuel Economy program and fuel economy rating identification of motor vehicles were introduced in 2005. The reference average fuel economy standards are 12.4 km/l for vehicles with engine displacement of 1500cc or less, and 9.6 km/l for displacement exceeding 1500cc. Fuel economy standards were set for domestic cars in 2006 and imported cars in 2009 if sales are less than 10,000. If sales of imported cars exceed 10,000 then these must meet US CAFÉ standards.
Australia	The Federal Chamber of Automotive Industry (FCAI) first established voluntary fuel economy standards for new vehicles sold in Australia in 1978. In 2003, FCAI members committed to a voluntary target of 6.8 l/100 km for petrol passenger cars by 2010. This represents an 18% improvement in the fuel efficiency of new vehicles between 2002 and 2010.
China	In 2004, China's National Development and Reform Commission announced that it would introduce mandatory fuel efficiency standards for passenger cars. These standards are initially classified into 16 categories based on vehicle weight. Standard values are set for each category. In addition, there are different standard values for manual transmissions and automatic transmissions. Compared with the Japanese regulation, which also has weight based categories, the Chinese standards tend to be more stringent for heavier passenger cars than lighter ones. Many consider the Chinese standards to be the third most stringent globally. Interesting to note is that it does not differentiate based on fuel, but by weight. In 2009, China announced that it will target a fleet wide average of 42.2 miles per gallon by the year 2015. In June 2010, the government approved subsidies for 16 car manufacturers to produce fuel efficient cars. Per car, 3000 yuan will be granted if it is proven that they save at least 20% fuel.
India	India's fuel economy standards are taking longer to develop because of institutional arrangements. In 2007 the Bureau of Energy Efficiency (BEE) and the Petroleum Conservation Research Association raised the idea of fuel economy standards in India. Government departments debated on which department should take the lead and whether India should develop CO_2 based standards or should have a mandatory or voluntary fuel labelling scheme. After the Prime Minister's office intervention, it was decided that implementation of mandatory fuel economy standards and fuel efficiency labelling for cars are needed to strengthen India's energy security. The Bureau of Energy Efficiency (BEE), an autonomous energy regulator under the Ministry of Power, were given the responsibility to develop the standards and labels. The Ministry of Shipping Road Transport and Highways (MoSRTH) will enforce these regulations. In January 2010, the Ministry of Environment and Forests announced that mandatory fuel efficiency standards will be introduced by the end of December 2011.

alternative fuel also one of the cleanest burning fuels. It usually used in vehicles as of compressed natural gas (CNG) or liquefied natural gas (LNG). Moreover, alcohol-based fuels such as ethanol and methanol which are made by fermentation process and distilling starch crops, such as corn and maize that uses to replace gasoline. These bio-fuels are capable of operating on either to mix or replace gasoline or natural gas, this allows alternative fuel users to operate as comfortable as using gasoline and diesel [39,40].

Indonesia is a leading exporter of LNG, with about 26.1% of the world's market share and 34.5% of the Asia and Pacific markets. CNG and LPG have been promoted as alternative fuels since 1987 and 1995, respectively [41]. Ethanol has also been introduced in Indonesia, but to date there is no data available on its uptake. In 2005, palm oil biodiesel (CPO) was tested and introduced as an additive to diesel with B_5 and B_{20} (5% and 20% CPO volume, respectively). Based on estimation, Indonesia's will be achieving 2.41 million kL by 2010, the country has achieved 24.4% of its objective [7,37,42]. Starting 2009, Malaysian hybrid cars received a 100% tax exemption of import duty and a 50% exemption of excise duty under a government measure to promote fuel economy. The hybrid cars to be certified by the Road Transport Department must achieve not less than a 50% increase in the city-fuel economy or not less than a 25% increase in combined city and highway fuel economy relative to a comparable vehicle under total internal combustion gasoline fuel. As a measure to conserve conventional transportation fuels, the government has allocated tax exemptions on necessary components and kits for natural gas vehicles [12,43]. Malaysian Palm Oil Board (MPOB) advised the Malaysian government to implement the use of blended diesel with 5% local refined, bleached and deodorized palm olein as a quick solution for the use as biofuel compared to transforming palm oil to their respective methyl esters which requires more operating cost and time. Thus, in early 2006, the government launched the B5 (which is the above stated blended diesel with 5% RBD palm olein), or more commercially termed as envodiesel [39,44,45]. Furthermore, Indonesia and Malaysia are also of great importance in recent years, particularly in producing bio-diesel [42,46]. The Malaysian government has been exploring the possibilities of using other sources of alternative energy such as hydrogen fuel cells, landfill gas, solar energy and incineration from municipal solid waste [43]. In Other Asian countries, the next goal of biofuels in Philippines is the proposed 25% E10 blending fuel by 2010 and Thailand's target is 3% blending of biodiesel [20,38,39,41,47–49].

5. The fuel economy initiatives

The fuel economy initiative aims to establish partnerships between governments and other organizations around the world to achieve vehicle fuel efficiency and reduce CO_2 emissions. The main

objectives of fuel economy initiative for vehicles can be considered as [50]:

(i) Work with governments to develop sound policies to encourage fuel economy improvement for vehicles produced and/or sold in their countries.
(ii) Work with stakeholders (such as auto makers) to better understand the potential for fuel economy improvements and solicit their support.
(iii) Support awareness initiatives to provide consumers and decision makers with information on options.

The comprehensive review of fuel economy initiative in some selected countries around the world are shown in Table 9 [12]. According to the Energy Information Administration (EIA), global fuel economy initiative has a target of 30% improvement fuel economy (reduction in l/100 km) in new cars worldwide by 2020, 50% by 2030 and leading to a 50% reduction in stock average fuel economy by 2050 (the “50 by 50” campaign) [51].

6. Fuel economy standards and labels in the ASEAN region

Fuel economy standards and labels are one of the best strategies to reduce energy utilization and help any country to reduce their pollution. Standards are procedures and regulations that prescribe a fuel economy level as criteria that manufacturers must meet in order to get the permission to sell their products in the market. Labelling is another measure that could play an important role in consumers' vehicle purchasing decisions between similar vehicles. Labelling accompanied by standards of an appropriate type and level of stringency may yield synergistic results. In order to set fuel economy standards and labels for vehicles, a regulatory authority must be developed [29,52–56]. The energy labels could contribute to further potential energy savings from the standards [27,57–60]. The purpose of evaluating standards and test method programs is to identify the areas of weakness in the programs design and implementation so that they can be strengthened in the future stage. The programs also aim to measure the impacts on vehicle efficiency, fuel consumption, operating costs, manufacturing, and the environmental impact. An evaluation to meet prioritized needs of time, cost, or accuracy [24]. Table 10 [12] provides an overview of the various government agencies involved in the development and setting of standards on vehicle emissions standards and fuel quality in different ASEAN member countries.

6.1. Malaysia

Malaysia has started to strive towards low carbon emissions recently through various green policies and energy efficiency (EE) programs. The energy scenario and various policies have been adopted in this country to mitigate CO_2 emission [61]. The government of Malaysia has formulated numerous energy-related policies throughout the years to ensure the long-term reliability and energy supply security for sustainability social-economic development for the country. The implemented policies are the National Energy Policy (1979), National Depletion Policy (1980) and Fuel Diversification Policy (1981, 1999) [43]. Moreover, the Malaysian government has developed several policies to control emissions from vehicles, such as [12]:

(i) Environmental Quality (Clean Air) Regulations 1978.
(ii) Environmental Quality (Control of lead concentration in automobile gasoline) Regulations 1985.
(iii) Environmental Quality (Control Emission from Diesel Engine) Regulation of September 1 1996.
(iv) Environmental Quality (Control of Emission from Gasoline Engines) Regulation on November 1 1996.

Euro 1 standards are in place for diesel vehicles while Euro 2 standards are in place for gasoline vehicles. Malaysia is moving towards the adoption of Euro 2 standards for diesel vehicles and Euro 3 standards for gasoline vehicles [62]. There is a mandatory six months inspection for commercial vehicles to check for safety and level of emissions. However, fuel economy standards have not been implemented yet.

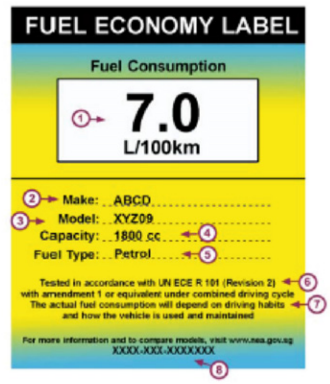
6.2. Indonesia

Indonesia's energy labelling program began in 1999. The energy labelling system was first considered for electrical appliances, initially for refrigerators [63,64]. However, fuel economy standards for vehicles are expected to be implemented in the near future, as they were confirmed at the Conference of the Parties (COP-15) in December 2009. The current emissions standards equivalent to Euro II was implemented in 2006. Indonesia expects to advance to Euro IV-equivalent emission standards by 2012 and working on plans to upgrade their refineries to produce Euro IV compliant gasoline during 2014–2016 [65].

There are several policies in Indonesia which are relevant to vehicle road worthiness and vehicle emissions. Indonesia's Act No. 14 (1992) on Road Traffic and Transport states that in order to prevent air and noise pollution, every motor vehicle must meet emission and noise standards. The newly enacted Act No. 22/2009 which replaces the Act No. 14/1992 on Traffic and Road Transportation is the legal basis for the management of land transportation, including the control of vehicle emissions. The Act stipulates that the vehicle emission test is an integral part of the roadworthiness test. Hence, the responsibility for vehicle emission testing lies with the transportation office, not with the environment office [12]. According to standards for new type motor vehicles and current production, government regulations mandate that new vehicles sold in Indonesia must comply with the Euro 2 standard started from January 2005 [66]. While for other vehicle categories (passenger car and motorcycle), the need for a road worthiness test will be covered by a separate Government Regulation which has to be issued. Furthermore, no proposed fuel economy standards in Indonesia have been implemented yet [12].

Table 10
Overview of National Ministries/Departments leading vehicle and fuel related policies development in ASEAN [12].

ASEAN countries	Vehicle emissions standards	Fuel quality	Vehicle tariffs/taxes and fuel subsidies/taxes	Energy efficiency and possibly fuel economy
Indonesia	Environment	Energy	Finance	Energy
Malaysia	Environment	Energy	Finance	Energy
Philippines	Environment	Energy	Finance	Energy
Singapore	Environment	Environment	Finance	Environment
Thailand	Environment	Energy	Finance	Energy
Vietnam	Transport	Environment	Finance	Transport



1. Fuel Consumption Measured - Fuel consumption is corrected to one decimal place. The unit for each individual fuel type is shown below.

Fuel type	Units
Diesel , LPG, Gasoline, Hybrid electric running on diesel, LPG, gasoline	Litres per 100km (L/100km)
Natural gas, Hybrid electric running on NG	kilograms per 100km (kg/100km)
Electric	Watt-hours per km (Wh/km)

2. Make of the motor vehicle

3. Model of motor vehicle

4. Model Engine Capacity Expressed in cc in whole digits

5. Fuel Type - Fuel type is defined below:

Type of motor vehicle	Fuel Type
Internal Combustion	Diesel, Gasoline
Hybrid	Natural gas Hybrid electric running on CNG Hybrid electric running on diesel, LPG, gasoline LPG
Electric	Electric

6. Test Standard The test standard used

7. Disclaimer - The following disclaimer applies to all motor vehicles: The actual fuel consumption will depend on driving habits and how the vehicle is used and maintained.

8. Registration Number - A unique number found on the registered model's COR, which is issued by NEA upon successful registration of the model.

Fig. 12. Fuel economy label for vehicles in Singapore [12,72,73].

6.3. Philippines

In The Philippines all new motor vehicles introduced in the market beginning from January 2008 which moved from pre-Euro to EURO 2 has significantly reduced emissions limits as specified in the revised emission standards for motor vehicles [62]. The requirement of passing an emission test before registration was put in place since 2003. The Philippines has issued a comprehensive National Energy and Efficiency and Conservation Program (NEECP) which aims to contribute towards the achievement of 60% energy self-sufficiency by 2010 and to reduce of 50.9 million tons of CO_2 emissions for the period from 2005 to 2014 [12]. However, the program does not include the development and implementation of fuel economy standards.

6.4. Thailand

In Thailand, the enactment of the Enhancement and Conservation of National Environmental Quality Act in 1992 was the beginning of the new era in air quality management. Air pollution has been identified by the public as a major environmental problem. This can be seen clearly in large communities and in rapidly developing areas in Thailand, where industry, transportation, traffic and construction are prevalent, as well as in areas where electricity power plant is situated [36,67,68]. Emission standards for on-road vehicles in Thailand has been formulated by the Pollution Control Department (PCD) and being adopted by the Ministry of Industry (MOI) and the Ministry of Science, Technology and Environment (MOSTE) [69]. In 2006, the Ministry of Environment also issued a longer list of air emission control for both combustion and non-combustion processes industries. These standards are based on European standards and emission test procedures for both gasoline and light duty diesel vehicles [70]. Since January 2007, all new heavy duty vehicles are required to comply with Euro 3 while new motorcycles should comply with regulations for powered two and three-wheeled vehicle (97/24/EC) which requires CO_2 emission to be no more than 3.5 g/km, and $HC + NO_x$ emission of no more than 1.8–2 g/km [69,70]. All in-use vehicles are required to renew registration annually. In 2005, a voluntary labelling program was launched by the Pollution Control Department to mitigate CO_2 emission and reduce fuel consumption and implemented to National Energy Policy Office as voluntary labelling Program in 2006 [12].

6.5. Vietnam

Vietnam is currently has an Euro 2 and sulphur levels regulation of 500 ppm in both gasoline and diesel under *Tie chuan* Vietnam specification fuel (TCVN 5689:2005 for diesel and TCVN 6776:2005 for gasoline). There are plans to move to Euro 3 in 2012 but current initiatives of the Clean Air Initiative (CAI-Asia Center) United Nations Environment Programme Partnership for Clean Fuels and Vehicles (UNEP PCFV) encourages leapfrogging to Euro 4. These organizations are working with the government to establish a roadmap for this purpose. No fuel economy standards have been implemented yet in this country [12].

6.6. Singapore

Since January 2001, all petrol- and diesel-driven vehicles are required to comply with the Euro 2 (European Commission (EC) Directive 96/69/EC) exhaust emission standards in Singapore. Starting from 1st July 2003, all motorcycles/scooters are required to comply with the exhaust emission standard as specified in EC Directive 97/24/EC before they can be registered for use in Singapore. From 1st October 2006, all new diesel vehicles are required to comply with the Euro IV emission standard. All taxis will be of Euro IV standard by 2014, while all public buses will only be so in 2023 [71].

In 2003, Singapore launched a voluntary Fuel Economy Labelling Scheme (FELS) to provide fuel economy information for buyers of passenger cars as presented in Fig. 12 [12,72,73]. By the end of 2007, vehicle modes which provide fuel economy information were still less than 20% [12]. From April 2009, it was made mandatory for car retailers to display fuel economy labels on cars in their showrooms [73]. In an effort to improve the scheme, fuel economy labelling was made mandatory for passenger cars as motor vehicles (not being second-hand goods) constructed for the carriage of [12]:

(i) Not more than 7 passengers (exclusive of the driver) and having an unladen mass not exceeding 3000 kg.
(ii) Goods and having an unladen mass not exceeding 2500 kg were included as "registrable goods" under the Environmental Protection and Management Act (EPMA) which are goods which are covered by the mandatory energy labelling.

Full implementation of the mandatory labelling for the specified types of motor vehicles was scheduled on April 1, 2009, but certain exemptions were allowed up to October 1, 2009. Cars which qualify for the extension are those which had already been approved by the Land Transport Authority but for which the fuel consumption data is not available yet [73].

6.7. The best of ASEAN countries

The development of fuel economy standards and labels can be summarised as the perceptions of fuel consumption and awareness to mitigate emission in ASEAN countries. Many ASEAN governments take the initiative to enhance global efforts to combat climate change and air pollution in the transportation sector by encouraging switching from fossil fuels to natural gas and promote the use of bio-fuels. Furthermore, Wills and Rovere [74] reported that the implementation of vehicle energy efficiency program with technological improvements in motor vehicles, fuel efficiency and the establishment of more rigorous fuel economy or emissions limits will all help to reduce GHG emissions.

Singapore is one of ASEAN countries that has implemented fuel economy standards and labels, these standards help them choose more fuel efficient vehicle models [12,72]. Moreover, transportation planning and strategies has considered public transport as the best choice to reduce demand for road space, to reach goods, service, activities and destination with faster access and to reduce distance travelled [73]. In 2001, Singapore also has promoted the green vehicles program by encouraging the purchase of hybrid and compressed natural gas (CNG) and Green Vehicle Rebate (GVR) [12]. In Malaysia, the transportation infrastructure and air quality is fairly good and its relatively high economic status has encouraged private motorized transportation in most cities in Malaysia. Malaysia has substantial rail and public transportation infrastructure compared with other ASEAN countries [75]. The voluntary labelling program should exist in Malaysia following the adopted international best practices with the establishment of fuel efficiency or GHG emissions goals. As policy recommendation, other ASEAN members such as Indonesia, Thailand, Philippines and Vietnam are required to learn from the existing policies, institutional arrangements and strengthen the emission measurement knowledge and capacity of fuel economy standard and labels.

7. Conclusion

The establishment of a common framework for fuel economy standards and labels policies and measures in the ASEAN has to be wholly owned by the ASEAN member countries. Despite the fact that different agencies are responsible for fuel economy developments in different ASEAN countries, the integration into national transport policies and link to other transport related policies (fuel quality, vehicle emissions, alternative/biofuels) will be essential. The fuel economy standards and labels are relatively cheap measures to influence consumer behaviour on the one hand and to induce a market transformation by encouraging car manufacturers to produce vehicles that are more efficient on the other hand. The experiences of other countries that have implemented fuel economy policies such as China and Japan show that fuel economy standards and labels has the potential to help in cutting fuel use and CO_2 emissions in those countries. Progress in enhancing fuel efficiency was achieved by advances in industry automotives areas, such as transmission, accessories, tires, weighted, aerodynamics and improving thermal efficiency. These improvements are dedicated to meet the standards of vehicle ahead of their adoption, and to accelerate the developments of fuel economy technology. This review indicates that the introduction of fuel economy standards and labels for vehicle in ASEAN countries is one of the most effective and communicative strategies to reach the targets. It also aims to provide efficient fuel consumption vehicles which can help to substantially reduce emissions from vehicle in the transportation sector. Fuel economy standards and labels also provide benefits to the national economy and environment in the future in ASEAN Countries. Finally, it has been found utilization of alternative fuels such as natural gas, propane, ethanol, methanol, biodiesel and hydrogen offers substantial benefits in reducing air pollutants and GHG emissions. Moreover, most of these fuels have been found to be more economically viable compared to fossil fuels.

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References

[1] Stevenson RS. An assessment of the design and effectiveness of the ASEAN Environmental Improvement Program. Journal of Cleaner Production 2007;12(3):227–36.
[2] United Nation (UN). Mandatory disclosure of automotive emissions; 2010. Available from: http://www.un.org/jsummit/html/sustainable_dev/p2_managing_resources/1908_mandatory_disclosure.pdf.
[3] Hirota K. Policy for better air quality in Asia; 2010 [cited 15.11.10]. Available from: http://jsrsai.envr.tsukuba.ac.jp/Annual_Meeting/M44/resume_a/rA05-4_hirota.pdf.
[4] ASEAN T. ASEAN automotive market; 2010 [cited 17.02.11]. Available from: http://trade.gov/static/ASEAN%20Automotive%20Market%20Final.pdf.
[5] Pundir BP. Fuel economy of Indian passenger vehicles – status of technology and potential FE improvements; 2008 [cited 15.11.10]. Available from: http://www.iitk.ac.in/me/New_Books/Fuel%20Economy.doc.
[6] Cheah L, Heywood J, Meeting US. Passenger vehicle fuel economy standards in 2016 and beyond. Energy Policy 2011;39(4):454–66.
[7] Transport Environment (T&E). Regulating CO_2 emissions of new cars; 2007 [cited 17.02.11]. Available from: www.transportenvironment.org/Downloads-req-getit-lid-474.html.
[8] Oliver HHG, Tian D, Zhang J. China's fuel economy standards for passenger vehicles: rationale, policy process, and impacts. Energy Policy 2009;37(11):4720–9.

[9] Environmental Protection Act. National environmental quality standards for motor vehicular exhaust and noise; 1997 [cited 13.11.10]. Available from: http://www.environment.gov.pk/pro_pdf/WPAPER-VES.pdf.
[10] International Energy Agency (IEA). Review Of International Policies For Vehicle Fuel Efficiency; 2008 [cited 06.12.10]; Available from: http://www.iea.org/papers/2008/Vehicle_Fuel.pdf.
[11] Timilsina GR, Hari BD. Regulatory instruments to control environmental externalities from the transport sector; 2009 [cited 25.12.10]; Available from: http://www.istiee.org/te/papers/N41/41_5_abs_TimilsinaDulal.pdf.
[12] Clean Air Initiative for Asian Cities. Improving vehicle fuel economy in the ASEAN region; 2010 [cited 08.12.10]. Available from: http://www.globalfueleconomy.org/Documents/Publications/wp1_asean_fuel_economy.pdf.
[13] Karki SK, Mann MD, Salehfar H. Energy and environment in the ASEAN: challenges and opportunities. Energy Policy 2005;33(4):499–509.
[14] Lean HH, Smyth R. CO_2 emissions, electricity consumption and output in ASEAN. Applied Energy 2010;87(6):1858–64.
[15] British Petroleum (BP). BP Statistical review of world energy June 2010 [20.10.10]. Available from: http://www.bp.com/productlanding.do?categoryId=6929&contentId=7044622; http://www.bp.com/statisticalreview.
[16] Hilmawan E, Said M. Energy efficiency standard and labeling policy in Indonesia; 2009 [cited 20.10.10]. Available from: http://eneken.ieej.or.jp/data/en/data/pdf/491.pdf.
[17] Fontaras GK, Karavalakis M, Tzamkiozis G, Pistikopoulos T, Ntziachristos P, Bakeas L, et al. Effects of low concentration biodiesel blend application on modern passenger cars. Part 1: Feedstock impact on regulated pollutants, fuel consumption and particle emissions. Environmental Pollution 2010;158(5):1451–60.
[18] Benjamin K, Sovacool BK. Energy policy and cooperation in Southeast Asia: the history, challenges, and implications of the trans-ASEAN gas pipeline (TAGP) network. Energy Policy 2010;37(6):2356–67.
[19] Yoo S-H. The causal relationship between electricity consumption and economic growth in the ASEAN countries. Energy Policy 2006;34(18):3573–82.
[20] Zhang ZX. Asian energy and environmental policy: promoting growth while preserving the environment. Energy Policy 2008;36(10):3905–24.
[21] Nelson PF, Tibbett AR, Day SJ. Effects of vehicle type and fuel quality on real world toxic emissions from diesel vehicles. Atmospheric Environment 2008;42(21):5291–303.
[22] Leinbach TR. Transport policies in conflict: deregulation, subsidies, and regional development in Indonesia. Transportation Research Part A: General 1989;23(6):467–75.
[23] United Nation (UN). Asia; 2010 [cited 13.11.10]. Available from: http://www.un.org/esa/gite/cleanfuels/asia.pdf.
[24] Lutsey N. Survey of vehicle mass-reduction technology trends and prospects; 2010 [13.11.10]. Available from: http://www.arb.ca.gov/msprog/levprog/leviii/meetings/051810/lutsey_its_may18_final.pdf.
[25] The International Council on Clean Transportation (ICCT). Emerging technologies for efficient, low-CO_2 automobiles [cited 13.11.10]. Available from: http://www.congresotransportesustentable.org/ponencias6/Lutsey%20Nic%3BEmerging%20technologies%20for%20_efficient%2C%20low%20CO2%20automobiles.pdf.
[26] Australian Transport Council and the Environment Protection and Heritage Council. Vehicle Fuel Efficiency Working Group; 2009 [cited 13.11.10]. Available from: http://w ww.coag.gov.au/coag_meeting_outcomes/2009-07-02/docs/vehicle_fuel_efficiency_working_group_final_report.pdf.
[27] ITB Group. Improving vehicle fuel economy and reducing vehicle emissions; 2009 [cited 13.11.10]. Available from: http://www.itbgroup.com/pdf/Newsletters/ITB_609_FuelEconEmissions.pdf.
[28] Bezdek RH, Wendling RM. Potential long-term impacts of changes in US vehicle fuel efficiency standards. Energy Policy 2005;33(3):407–19.
[29] Mahlia TMI, Saidur R, Memon LA, Zulkifli NWM, Masjuki HH. A review on fuel economy standard for motor vehicle with the implementation possibilities in Malaysia. Renewable and Sustainable Energy Reviews 2010;14(9):3092–9.
[30] Howard M. Production and process technology: the impact of vehicle design on rapid build to order; 2000 [cited 13.11.10]. Available from: http://www.3daycar.com/mainframe/publications/library/vehdesfull.pdf.
[31] United Nations Environmental Program (UNEP). ASEAN State of the Environment Report. Bangkok, Thailand; 2000.
[32] University of California Transportation Center (UCTC). The potential of turboprops for reducing aviation fuel consumption Megan Smirti Ryerson; 2010 [cited 15.11.10]. Available from: http://www.uctc.net/papers/883.pdf.
[33] United Nation Environment Program (UNEP) Chemicals. Lead in gasoline-international pattern of use; 2010 [cited 30.11.10]. Available from: http://www.chem.unep.ch/pops/pdf/lead/leadgas.pdf.
[34] International Fuel Quality Center (IFQC). Trends & developments in European automotive fuel quality; 2004 [cited 30.11.10]. Available from: http://www.unep.org/pcfv/pdf/RomeSDDpres.pdf.
[35] United Nation Environment Program (UNEP) Chemicals. Sub-Saharan Africa Lead Matrix; 2010 [cited 30.11.10]. Available from: http://www.unep.org/pcfv/PDF/MatrixAfricaLead-March2010.pdf.
[36] United Nation (UN). Environmental policies in Thailand and their effects; 2010 [cited 09.12.10]. Available from: http://www.un.org/esa/gite/iandm/viroatpaper.pdf.
[37] Chang HJ, Cho GL, Kim YD. The economic impact of strengthening fuel quality regulation–reducing sulfur content in diesel fuel. Energy Policy 2006;34(16):2572–85.
[38] Liu H, He K, He D, Fu L, Zhou Y, Walsh MP, et al. Analysis of the impacts of fuel sulfur on vehicle emissions in China. Fuel and Energy Abstracts 2008;87(13–14):3147–54.
[39] Pourkhesalian A, Shamekhi MA, Salimi HF. Alternative fuel and gasoline in an SI engine. Fuel 2010;89(5):1056–63.
[40] Difiglio C, Fulton L. How to reduce US automobile greenhouse gas emissions. Energy 2005;25(7):657–73.
[41] Das A, Ahlgren EO. Implications of using clean technologies to power selected ASEAN countries. Energy Policy 2010;38(4):1851–71.
[42] Zhou A, Thomson E. The development of biofuels in Asia. Applied Energy 2009;86:S11–20.
[43] Mohamed AR, Lee KT. Energy for sustainable development in Malaysia: energy policy and alternative energy. Energy Policy 2006;34(15):2388–97.
[44] Jayed MH, Masjuki HH, Kalam MA, Mahlia TMI, Husnawan M, Liaquat AM. Prospects of dedicated biodiesel engine vehicles in Malaysia and Indonesia. Renewable and Sustainable Energy Reviews 2011;15(1):220–35.
[45] Sumathi S, Chai SP, Mohamed AR. Utilization of oil palm as a source of renewable energy in Malaysia. Renewable and Sustainable Energy Reviews 2008;12(9):2404–21.
[46] Abdullah K. Renewable energy conversion and utilization in ASEAN countries. Energy 2005;30(2–4):119–28.
[47] Silalertruksa T, Gheewala SH. Environmental sustainability assessment of bio-ethanol production in Thailand. Energy 2009;34(11):1933–46.
[48] Silalertruksa T, Shabbir H, Gheewala SH, Sagisaka M. Impacts of Thai bio-ethanol policy target on land use and greenhouse gas emissions. Applied Energy 2009;86:S170–7.
[49] Siriwardhana M, Opathella GKC, Jha MK. Bio-diesel: initiatives, potential and prospects in Thailand: a review. Energy Policy 2009;37(2):554–9.
[50] 50 B Y50 Global Fuel Economy Initiative. Making cars 50% more fuel efficient by 2050 worldwide; 2011 [cited 17.02.11]. Available from: http://www.fiafoundation.org/publications/Documents/50BY50_report.pdf.
[51] Takao O. The global fuel economy initiative: background and purpose; 2009 [cited 17.02.11]. Available from: http://www.unece.org/trans/doc/2009/wp29/WP29-147-16e.pdf.
[52] Silitonga AS. Techno economic analysis and environmental impact of implementation of fuel economy standards and labels for passenger cars in Indonesia. M.Eng. Thesis. University of Malaya, Kuala Lumpur, Malaysia; 2009.
[53] Mahlia TMI, Masjuki HH, Choudhury IA. Theory of energy efficiency standards and labels. Energy Conversion and Management 2002;43(6):743–61.
[54] Liaquat AMM, Mahila TMI, Masjuki HH. A review on fuel economy standards and labels for motor vehicles: implementation possibility in Pakistan. Journal of Applied Sciences 2007;7:626–32.
[55] Atabani AE, Irfan AB, Mekhilef S, Silitonga AS. A review on global fuel economy standards, labels and technologies in the transportation sector. Renewable and Sustainable Energy Reviews 2011;15(9):4586–610.
[56] Silitonga AS, Atabani AE, Mahlia TMI, Sebayang AH. Techno-economic analysis and environmental impact of fuel economy labels for passenger cars in Indonesia. Renewable and Sustainable Energy Reviews 2011;15(9):5212–7.
[57] Du Pont PT. Energy policy and consumer reality: the role of energy in the purchase of household appliances in the US and Thailand. Ph.D. dissertation. University of Delaware; 1998.
[58] Terry Oliver T, Lew D, Redlinger R, Prijyanoda C. Global energy efficiency and renewable energy policy options and initiatives. Energy for Sustainable Development 2001;V(2).
[59] Wiel S, McMahon JE. Governments should implement energy-efficiency standards and labels-cautiously. Energy Policy 2003;31(13):1403–15.
[60] Wiel S, Egan C, Cava MD. Energy efficiency standards and labels provide a solid foundation for economic growth, climate change mitigation, and regional trade. Energy for Sustainable Development 2006;X(3).
[61] Oh TH, Chua SC. Energy efficiency and carbon trading potential in Malaysia. Renewable and Sustainable Energy Reviews 2010;14(7):2095–103.
[62] Asian Development Bank (ADB) and the Clean Air Initiative for Asian Cities (CAI-Asia). Country Synthesis Report on Urban Air Quality Management Malaysia; 2006 [cited 09.12.10]; Available from: http://cleanairinitiative.org/portal/system/files/documents/malaysia_0.pdf.
[63] The National Appliance and Equipment Energy Efficiency Committee (NAEEEC). Energy labeling and standards programs throughout the world; 2004 [cited 15.11.10]; Available from: http://www.earthadvantage.org/assets/uploads/harrington_label_report_2004.pdf.
[64] Cousins SH, Bueno JG, Coronado OP. Powering or de-powering future vehicles to reach low carbon outcomes: the long term view 1930–2020. Journal of Cleaner Production 2007;15(11–12):1022–31.
[65] The Institute of Energy Economics Japan (IEEJ). Compendium of Energy Efficiency Policies of APEC Economies; 2010 [cited 15.11.10]; Available from: http://www.ieej.or.jp/aperc/CEEP/Indonesia.pdf.
[66] Gallachoir BPO, Howley M, Cunningham S, Bazilian M. How private car purchasing trends offset efficiency gains and the successful energy policy response. Energy Policy 2009;37(10):3790–802.
[67] United Nation (UN). Atmosphere/air pollution; 2010 [cited 09.12.10]; Available from: http://www.un.org/esa/agenda21/natlinfo/countr/thai/atmosphere.pdf.
[68] Wangwongwatana S. Cleaner Fuel and Vehicle Emission Standards in Thailand; 2004 [cited 09.12.10]; Available from: http://www.walshcarlines.com/pdf/Supat%20Clean%20Fuels%20and%20Vehicles%20in%20Thailand%20.pdf.
[69] Diesel net. Emission Standards Thailand: On-Road Vehicles and Engines; 2010 [cited 09.12.10]; Available from: http://www.dieselnet.com/standards/th/.

[70] Clean Air Initiative for Asian Cities (CIA-Cities). Thailand Country Profile; 2009 [cited 09.12.10]; Available from: http://www.indiaenvironmentportal.org.in/files/Thailand_Country_Profile_2009.pdf.
[71] Asian Development Bank (ADB) and the Clean Air Initiative for Asian Cities (CAI-Asia). Country Synthesis Report on Urban Air Quality Management Singapore; 2006 [cited 28.12.10]; Available from: http://cleanairinitiative.org/portal/system/files/documents/singapore_0.pdf.
[72] Ministerial Conference on Global Environment and Energy in Transport (MEET). Efficient and Sustainable Land Transport in Singapore; 2009 [cited 07.12.10]; Available from: http://www.mlit.go.jp/kokusai/MEET/documents/MEETFUM/S4-Singapore.pdf.
[73] Wong K. Environmentally Sustainable Transport – Singapore's Experience; 2009 [cited 09.12.10]; Available from: http://www.uncrd.or.jp/env/4th-regional-est-forum/Presentations/18_BS5_Singapore.pdf.
[74] Wills W, Rovere ELL. Light vehicle energy efficiency programs and their impact on Brazilian CO_2 emissions. Energy Policy 2010;38(11):6453–62.
[75] Clean Air Initiative for Asian Cities (CAI-Asia). Country Synthesis Report on Urban Air Quality Management, Malaysia; 2006 [cited 09.12.10]; Available from: http://www.adb.org/Documents/Reports/Urban-Air-Quality-Management/malaysia.pdf.